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Juvenile American Plaice on the Grand Banks, NAFO Divisions 3LNO

by

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Introduction

The greatest abundance of American plaice in the Northwest Atlantic occurs on the Grand Bank off Newfoundland, NAFO Div. 3LNO. The fishery, which has yielded an average 40,000 t during the last 2 years, occurs mainly on the northern part of the Bank (Div. 3L) in depths of 75 to 185 m, along the eastern edge (Div. 3N) in depths of 70-275 m, and to a lesser extent on the southwestern part of the Bank (Div. 3Ø) in depths of 70-185 m (Pitt, 1975; Walsh, 1982) (Fig. 1).

Walsh (1982) proposed that both juvenile and adult plaice, in catches from spring groundfish surveys, were concentrated in the same areas of the Grand Bank. Since 1985 directed juvenile flatfish surveys on the shallow plateau of the Grand Banks inside of the 91 m (50 fath.) depth contour have identified a proposed nursery area for the southern Grand Bank population on the "Tail" of the Bank, NAFO Div. 3N (Walsh and Brodie, 1988; Walsh, 1989, 1990). In 1989 and 1990 the juvenile flatfish survey was extended into the slope waters of the Bank, to a depth of 183 m (100 fath.), to investigate the range of distribution of juvenile plaice in the southern area and to look for other possible nursery areas not sampled.

This paper will report on the findings of the 1990 survey and contrast distribution of juveniles with distribution of catches from surveys in 1985-89.

Materials and Methods

Survey design

Annual juvenile flatfish surveys of the Grand Bank were started in 1985. The main purpose of the survey was to determine year-clear strength of juvenile American plaice and yellowtail flounder as early as possible for the management of the resource. From 1985 to 1988, the survey area incorporated the entire Grand Bank inside the 91-m isobath, NAFO Div. 3L, 3N, and 3Ø (Fig. 1); and in 1989 and 1990 it was expanded out to the 183-m isobath to investigate distribution of juvenile plaice in deep water. The stratified-random trawl survey for juveniles consisted of 37 strata on the Grand Bank designated by 1° X 1° squares (Fig. 1). This stratification scheme has also been in place for annual spring Canadian groundfish surveys of the Grand Bank since 1971. The number of fishing hauls was proportioned according to the area of each stratum, and stations were randomly derived prior to each cruise. Since data on gear efficiency was not available, only relative abundance estimates were derived using a swept area model.

Survey gear and time

The survey gear used was a two-bridle Yankee 41 (80/104) shrimp trawl with a mesh size of 38 mm throughout and equipped with a 12-mm stretched mesh liner in the codend. The groundgear was rigged with 30-cm rubber rollers in the bosum, 30-cm rubber bunts in the quarters, and 11-cm rubber discs in the wing ends. The standard towing speed used, measured by Doppler speed log, was 2.5 knots with each haul being 30-minutes duration (on-bottom time), covering an average distance of 1.25 miles as calculated from Loran C navigation. At each fishing station, a surface-to-bottom temperature profile was taken with an XBT (Expendable Bathythermograph) from 1985 to 1988 and a trawl mounted CTD system in 1989 and 1990 and bottom depth was recorded from sounder records. The surveys were carried out during the last week in August and the first 2 weeks in September 1985, 1986, 1988, 1989, and 1990 and November 1-13 in 1987 aboard the R.V. WILFRED TEMPLEMAN, a 50-m stern trawler. Five hundred seventy-three (573) successful fishing hauls were made during the combined period of 1985-89. In the 1990 survey 198 successful sets were completed in Div. 3LNO out to the 183 m depth contour.

All of the catch was sorted by species and weighed. All plaice were measured to the nearest centimeter (total length). Otoliths were removed for ageing. Fish were classified as juveniles based on the age they began to mature and for this species this was approximately age 5. All analyses of the data were done on a 1-cm size category using SAS software (SAS Institute Inc. 1985).

Standard number per haul of different age groups - i.e., juveniles and aults - were contoured to represent spatial distribution. These data points describe a three-dimensional surface with latitude, longitude, and density; and the surface formed is defined by Delaunay triangles. The algorithm used to define these triangles is taken from Watson (1982). This shading contour program can be used to plot irregular-spaced data (G. A. P. Black 1988, Department of Fisheries and Oceans, Nova Scotia; pers. comm.).

Results

Table 1 shows average catch (numbers and weights) of American plaice catches in the 1985-90 juvenile surveys. Highest average catches in numbers were consistently found in stratum 360 in Div. 3N and stratum 353 in Div. 3Ø at the "Tail of the Bank". With the expansion in 1989 and 1990 to the slope waters of the Bank (93-183 m) other strata have shown high average numbers-per-tow, in particular strata 364, 370, and 385 on the northern slope of Div. 3L; stratum 359 on the southern slope of Div. 3N; and stratum 339 (Whale Deep) in Div. 3Ø. With only the 1989 and 1990 have extended coverage surveys, the juvenile surveys were able to give two point estimates for comparison of the 1989 and 1990 abundance and biomass in each division. Division 3L abundance and biomass were comparable during both years; while although the biomass was up in Div. 3N there was a decrease in abundance; and a small decrease in abundance and biomass was seen in Div. 3Ø.

Tables 2-4 show the age by age composition of the 1989 and 1990 surveys. The 1985 and 1986 year-classes in Div. 3L, Div. 3N, and Div. 3Ø appeared relatively strong in the comparison between both years. It is worth noting that in the 1990 survey of Div. 3N the numbers of plaice age 7-15 years showed an increase instead of a decrease as one would expect and hence the total population size of 7+ plaice is twice as high as in 1989. A check of the population sizes of various strata revealed that 56% of plaice age 7+ were found in strata 373 and 362 in the northern region of Div. 3N in 1990, up from 43% in 1989 and it may be possible that catches in this area inflated the estimates of ages 7-15 years. However, Table 5 shows the population structure of plaice caught in stratum 360 on the "Tail" of the Bank and it is evident that the above trend is not repeated here. During past assessments this stratum had been selected to monitor changes in abundance on the "Tail of the Bank". In the 1990 survey the 1986 year-class at age 4 is the second largest in the time series only to the 1985 year-class at age 4 in the 1989 survey. The 1985 year-class at age 5 is the largest recorded in the time series in the 1990 survey. Both of these year-classes have continuously shown to be strong since they first appeared at age 1 (Fig. 2). The 1987 year-class, which in 1989 had the largest population size at age 2 in the time series, may have some promise, but at age 3 in the 1990 survey it is not as large at the same age as the strong 1985 and 1986 year-classes which appeared in the 1988 and 1989 surveys.

Tables 6 and 7 contain information on age by age densities using average catch-per-tow of plaice in selected areas of the Grand Bank in the 1989 and 1990 surveys which have the extended coverage. Walsh (1990) proposed three areas of concentration of juveniles on the Grand Bank based on data from the 1989 surveys. These areas were the northern slope of Div. 3L, the "Tail of the Bank" in Div. 3N and Whale Deep in Div. 3Ø. Average catch-per-tow of age 1 plaice in the 1989 and 1990 surveys were extremely low in the selected strata on the northeast slope of Div. 3L (Table 6) when compared to catches in Whale Deep and the "Tail of the Bank" (Table 7). The catches of age 2 were slightly lower in comparison, however, catches of juveniles age 3, 4, and 5 years were comparable. The difference between catches of age 1 were not related to availability but probably vulnerability. Table 8 shows the mean size at age of juveniles 1-5 years from each division. Mean size of age 1 in Div. 3L are 5 cm while in Div. 3N age 1 are 7 cm and in Div. 3Ø, age 1 are 7 cm. The smaller sizes at age 1 in Div. 3L mean that these fish are probably less vulnerable to capture because of gear selectivity, and this is likely to be the reason for the lower population sizes at these ages in Div. 3L.

Tables 9 and 10 contain age by age composition for the selected strata of the northern slope of Div. 3L, the "Tail of the Bank", and Whale Deep for 1989 and 1990 surveys. The 1985 and 1986 year classes appear dominant in both years. In both surveys of Div. 3L, 81-94% of total abundance of juveniles 1-5 years are located in these strata along with large concentrations of older plaice (Table 9) (Fig. 3-6). In Div. 3Ø where stratum 339 (Whale Deep) and stratum 353 have large concentrations of juveniles, the percentages of the total abundance at age for Div. 3Ø ranged from 27% to 50% in both surveys. Similar to Div. 3L the adults were also concentrated in these areas (Table 10). Although both strata contain high catches of juveniles, in particular age 1 and 2 year olds, other strata on the western slope, i.e. strata 331, 332, 338, 337, and 354 and stratum 329 in the 1989 survey (not sampled in 1990) contain smaller amounts (Fig. 3-6). In Div. 3N strata 359 and 360 were examined for distribution of juveniles in the catches in both years. Seventy-four to ninety-five percent

of the total abundance of juveniles in Div. 3N were found in these two strata, mixed with the adult population (Table 10) (Fig. 3-6).

Discussion

The available information shows that there are three possible areas of concentrations of juvenile American plaice: northern slope of Div. 3L, "Tail of the Bank" in Div. 3N, and Whale Deep in Div. 3Ø. Low densities of 1 and 2 year old plaice in the northern slope of Div. 3L are attributed to size-dependent selectivity of the survey trawl. In Div. 3L juveniles in the first 3 years of life inhabit average depths of 130-140 m and average temperature of -1.2°C; similarly in Whale Deep area the average depths range from 105 to 110 m and slightly warmer temperatures of -0.2° to -0.4°C (Table 11). In contrast juveniles on the "Tail of the Bank" have shallower distribution from an average depth of 70-72 m and much warmer waters with an average temperature of 2-3°C.

The 1985 and 1986 year-classes, which were seen to be strong in stratum 360 of Div. 3N throughout the entire time series of the survey, appear to be strong in the Whale Deep and the northern slope of Div. 3L, indicating that there is synchrony in recruiting of Grand Bank American plaice in the different areas. These 2 year-classes are also reported strong in the 1991 yellowtail flounder assessment (this meeting).

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Table 1. Average numbers and weights of American plaice caught during juvenile surveys 1985-90.

Div.	Stratum	Category	1985[a]	1986[a]	1987[a]	1988[a]	1989	1990
3Ø	330	No. of sets	-	-	-	2	7	7
		Av. no./set	-	-	-	24.48	355.06	244.86
		Av. wt./set	-	-	-	40.47	80.35	186.71
3Ø	331	No. of sets	-	-	-	2	2	2
		Av. no./set	-	-	-	6.99	305.00	749.00
		Av. wt./set	-	-	-	2.50	113.75	123.06
3Ø	338	No. of sets	-	3	-	6	6	4
		Av. no./set	-	33.00	-	89.60	289.00	99.25
		Av. wt./set	-	15.50	-	14.49	36.87	17.87

Table 1. (Cont'd.).

Div.	Stratum	Category	1985[a]	1986[a]	1987[a]	1988[a]	1989	1990
3Ø	340	No. of sets	-	-	-	3	6	7
		Av. no./set	-	-	-	19.79	60.17	38.14
		Av. wt./set	-	-	-	6.09	36.87	19.16
3L	350	No. of sets	5	6	-	5	8	4
		Av. no./set	43.60	106.67	-	273.99	71.63	27.50
		Av. wt./set	39.80	93.92	-	69.25	51.44	33.30
3Ø	351	No. of sets	3	9	-	7	8	9
		Av. no./set	66.00	81.33	-	48.11	334.25	390.99
		Av. wt./set	35.00	36.28	-	39.47	54.54	70.23
3Ø	352	No. of sets	-	13	-	11	14	16
		Av. no./set	-	88.62	-	120.09	150.14	106.46
		Av. wt./set	-	37.30	-	28.22	39.06	35.94
3Ø	353	No. of sets	-	5	-	4	3	4
		Av. no./set	-	794.00	-	700.71	770.33	1306.00
		Av. wt./set	-	51.33	-	145.90	108.07	113.06
3N	360	No. of sets	3	14	19	20	19	21
		Av. no./set	189.67	1823.93	1043.14	1271.32	3015.54	1427.81
		Av. wt./set	29.00	86.67	47.28	83.37	165.56	113.05
3N	361	No. of sets	6	8	8	6	9	10
		Av. no./set	31.50	29.88	59.08	64.12	53.78	71.36
		Av. wt./set	24.17	19.69	41.80	24.90	188.50	38.18
3N	362	No. of sets	9	7	2	6	8	9
		Av. no./set	63.78	62.57	201.84	135.76	177.50	162.14
		Av. wt./set	37.72	34.71	84.19	45.55	38.44	90.19
3L	363	No. of sets	5	5	-	6	7	4
		Av. no./set	161.00	119.40	-	53.79	315.43	549.50
		Av. wt./set	56.30	42.61	-	27.65	88.70	77.86
3L	371	No. of sets	4	-	-	5	4	3
		Av. no./set	252.00	-	-	74.34	67.00	96.67
		Av. wt./set	102.13	-	-	41.45	33.50	40.97
3L	372	No. of sets	9	8	-	8	8	4
		Av. no./set	98.28	108.50	-	97.80	97.88	73.00
		Av. wt./set	72.09	90.38	-	55.02	38.43	45.23
3N	373	No. of sets	10	7	-	8	8	9
		Av. no./set	399.80	182.93	-	51.59	95.25	198.00
		Av. wt./set	313.34	139.68	-	35.93	54.13	123.16
3N	374	No. of sets	4	4	-	4	3	4
		Av. no./set	147.25	408.50	-	166.12	173.33	93.25
		Av. wt./set	62.63	218.25	-	53.98	37.00	36.31
3N	375	No. of sets	7	5	7	9	8	11
		Av. no./set	57.71	24.38	48.96	23.54	21.63	50.50
		Av. wt./set	67.43	31.98	69.54	17.45	17.06	50.58
3N	376	No. of sets	2	4	10	12	9	11
		Av. no./set	60.00	221.75	347.63	674.98	71.89	110.36
		Av. wt./set	45.50	284.31	18.75	52.81	18.89	23.01
3N	383	No. of sets	4	-	-	4	3	3
		Av. no./set	236.00	-	-	106.42	268.33	396.33
		Av. wt./set	75.63	-	-	42.59	52.50	65.49
3L	384	No. of sets	4	-	-	5	4	2
		Av. no./set	282.25	-	-	191.45	372.25	246.50
		Av. wt./set	105.45	-	-	88.33	72.41	105.15

Table 1. (Cont'd.).

Div.	Stratum	Category	1985[a]	1986[a]	1987[a]	1988[a]	1989	1990
3L	328	No. of sets	-	-	-	-	3	-
		Av. no./set	-	-	-	-	159.85	-
		Av. wt./set	-	-	-	-	15.00	-
3Ø	329	No. of sets	-	-	-	-	4	-
		Av. no./set	-	-	-	-	803.63	-
		Av. wt./set	-	-	-	-	132.21	-
3Ø	332	No. of sets	-	-	-	-	4	2
		Av. no./set	-	-	-	-	592.25	515.00
		Av. wt./set	-	-	-	-	80.53	42.67
3Ø	337	No. of sets	-	-	-	-	2	3
		Av. no./set	-	-	-	-	357.00	501.33
		Av. wt./set	-	-	-	-	45.38	37.58
3Ø	339	No. of sets	-	-	-	-	2	3
		Av. no./set	-	-	-	-	2960.50	2666.33
		Av. wt./set	-	-	-	-	449.60	253.35
3L	341	No. of sets	-	-	-	-	4	5
		Av. no./set	-	-	-	-	1194.50	202.80
		Av. wt./set	-	-	-	-	220.88	41.20
3L	342	No. of sets	-	-	-	-	2	-
		Av. no./set	-	-	-	-	223.00	-
		Av. wt./set	-	-	-	-	51.25	-
3L	343	No. of sets	-	-	-	-	2	-
		Av. no./set	-	-	-	-	59.00	-
		Av. wt./set	-	-	-	-	7.50	-
3L	348	No. of sets	-	-	-	-	7	4
		Av. no./set	-	-	-	-	1562.50	773.90
		Av. wt./set	-	-	-	-	146.84	104.21
3L	349	No. of sets	-	-	-	-	5	7
		Av. no./set	-	-	-	-	1341.40	492.57
		Av. wt./set	-	-	-	-	199.62	93.57
3Ø	354	No. of sets	-	-	-	-	2	3
		Av. no./set	-	-	-	-	472.50	692.00
		Av. wt./set	-	-	-	-	80.53	82.46
3N	359	No. of sets	-	-	-	-	2	3
		Av. no./set	-	-	-	-	2395.50	898.18
		Av. wt./set	-	-	-	-	99.55	51.08
3L	364	No. of sets	-	-	-	-	11	5
		Av. no./set	-	-	-	-	1406.53	2361.60
		Av. wt./set	-	-	-	-	113.02	292.07
3L	365	No. of sets	-	-	-	-	4	3
		Av. no./set	-	-	-	-	1854.75	912.67
		Av. wt./set	-	-	-	-	95.08	89.76
3L	370	No. of sets	-	-	-	-	6	3
		Av. no./set	-	-	-	-	1703.83	1119.33
		Av. wt./set	-	-	-	-	87.53	145.37
3N	382	No. of sets	-	-	-	-	2	3
		Av. no./set	-	-	-	-	48.00	584.00
		Av. wt./set	-	-	-	-	5.25	46.51
3L	385	No. of sets	-	-	-	-	5	4
		Av. no./set	-	-	-	-	1085.80	2084.00
		Av. wt./set	-	-	-	-	69.33	87.62

Table 1. (Cont'd.).

Div.	Stratum	Category	1985[a]	1986[a]	1987[a]	1988[a]	1989	1990
3L	390	No. of sets	-	-	-	-	4	3
		Av. no./set	-	-	-	-	284.00	234.33
		Av. wt./set	-	-	-	-	50.91	41.27
3L Biomass (000 t)			-	-	-	-	253.7	248.9
3N Biomass (000 t)			-	-	-	-	99.7	126.6
3Ø Biomass (000 t)			-	-	-	-	147.2	127.0
Total Biomass			-	-	-	-	500.7	502.6
3L Abundance (10^{-6})			-	-	-	-	2230.6	2015.4
3N Abundance (10^{-6})			-	-	-	-	1221.9	706.3
3Ø Abundance (10^{-6})			-	-	-	-	855.7	693.5
Total Abundance (10^{-6})			-	-	-	-	4308.2	3415.2

[a]Incomplete survey.

Table 2. Division 3L abundance at age (Nos. X 10^{-6}) of plaice in the 1989 and 1990 surveys.

Age	1989	1990
1	4.1	2.2
2	84.0	28.6
3	456.9	171.4
4	486.7	476.3
5	199.7	474.9
6	223.5	198.1
7	220.2	194.3
8	238.9	180.8
9	196.2	142.1
10	70.1	77.8
11	30.2	41.9
12	13.8	19.1
13	4.1	5.7
14	1.4	1.4
15	0.5	0.6
Unknown	0.1	0.2
Total		
1+	2,230.6	2,015.4
5+	1,198.7	1,171.0
7+	775.4	501.1
1 to 5	1,231.5	1,153.3

Table 3. Division 3N abundance at age (Nos. X 10^{-6}) of plaice in the 1989 and 1990 surveys.

Age	1989	1990
1	52.5	35.2
2	254.1	78.5
3	405.6	129.5
4	332.5	192.0
5	94.5	143.8
6	35.4	39.0
7	13.4	20.0
8	9.7	13.9
9	5.8	14.0
10	6.7	12.0
11	5.6	9.9
12	2.9	7.3
13	2.1	5.0
14	0.8	3.9
15	0.2	1.5
16	0	0.6
Unknown	0.1	
Total		
1+	1,221.9	706.3
5+	177.1	271.0
7+	47.2	88.1
1 to 5	1,139.1	579.0

Table 4. Division 3Ø abundance at age (Nos. X 10^{-6}) of plaice in the 1989 and 1990 surveys.

Age	1989	1990
1	83.7	41.2
2	110.5	138.3
3	200.7	80.5
4	141.3	159.9
5	72.7	107.8
6	57.2	44.5
7	57.7	32.5
8	36.5	24.0
9	34.2	17.1
10	22.3	15.7
11	18.8	12.8
12	10.0	9.4
13	3.9	5.5
14	3.3	2.6
15	1.8	1.1
16	0.7	0.5
17	0.2	
Unknown		
Total		
1+	855.6	693.5
5+	319.4	273.5
7+	189.4	121.2
1 to 5	608.9	527.8

Table 5. Abundance at age (Nos. x 10^{-6}) for Stratum 360 from surveys in 1985-90.

Age	1985[a]	1986	1987	1988	1989	1990
1	12.1	165.4	95.2	10.1	48.9	29.1
2	20.7	144.9	144.1	100.5	212.8	58.5
3	8.6	127.1	58.1	172.3	327.7	93.2
4	3.1	53.4	21.8	73.9	275.9	137.1
5	4.1	19.9	4.7	26.6	77.3	97.4
6	3.1	25.2	3.5	8.3	24.6	23.6
7	2.0	11.6	1.5	4.8	5.2	7.9
8	1.0	4.7	0.7	3.5	2.3	3.5
9	1.5	1.8	0.4	1.3	0.9	1.4
10	1.5	1.1	0.2	0.6	0.8	0.7
11	0.7	0.7	0.2	0.6	0.6	0.4
12	0.7	0.6	0.2	0.4	0.5	0.2
13	0.4	0.5	0.2	0.4	0.4	0.2
14	0.2	0.3	0.2	0.2	0.2	0.2
15		0.2				
16						
17						
Total						
1+	59.8	557.7	331.7	403.5	978.3	453.6
5+	15.2	66.6	11.8	46.7	112.8	135.5
7+	8.0	21.5	3.6	11.8	10.9	14.5
1 to 5	48.6	510.7	323.9	383.4	942.6	415.3

[a]Poor coverage in 1985 (three sets in the northern section only).

Table 6. Mean catch-per-tow at age from plaice catches in the deepwater strata (93-183) on the north and northeast slope of Division 3L in juvenile surveys of 1989 and 1990.

	Stratum 348		Stratum 349		Stratum 364		Stratum 365		Stratum 370		Stratum 385	
Age	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990
1	0.9	0.6	0.6	0.3	1.2	1.4	1.1	2.4	3.45	0.3	8.0	3.9
2	42.2	2.8	17.2	0.7	47.5	23.7	129.3	5.9	103.5	15.3	77.0	64.5
3	238.9	30.1	137.8	5.5	363.8	154.2	530.9	52.5	562.9	78.7	337.0	355.2
4	281.5	113.8	180.9	28.4	390.9	564.9	485.9	192.6	565.7	206.5	283.2	748.5
5	186.7	156.4	86.6	68.8	134.4	658.1	196.0	252.2	154.7	237.5	93.6	483.2
6	228.6	106.4	144.8	56.3	121.9	236.4	191.9	133.8	110.7	120.5	95.1	153.9
7	228.9	124.8	199.8	86.8	98.6	221.1	142.6	121.6	65.8	140.8	69.2	107.8
8	201.8	114.4	297.9	111.8	113.9	206.7	103.6	74.3	52.8	141.0	51.2	66.6
9	107.4	82.1	218.5	86.7	92.3	161.2	49.3	47.1	50.7	104.4	41.1	37.7
10	25.7	28.9	40.7	32.2	29.9	96.8	13.9	24.6	22.1	47.2	19.4	13.3
11	7.7	9.8	9.7	11.4	8.9	51.3	7.9	5.8	9.2	18.2	6.9	4.1
12	3.2	3.9	5.3	3.1	2.9	22.3	1.7	4.2	2.9	5.1	3.1	2.6
13	1.0	0.0	1.7	0.4	0.2	4.9	0.1	0.7	1.0	1.1	0.8	0.4
14	0.3	0.0	0.0	0.2	0.0	0.8	0.1	0.0	0.2	0.3	0.2	0.0
	1554.8	773.9	1341.5	492.63	1406.7	2404.2	1854.7	917.6	1705.6	1116.7	1085.8	2041.9

Table 7. Mean catch-per-tow at age for plaice catches on the "Tail" of the Bank (Strata 353 and 360) and Whale Deep (Stratum 339) in the 1989 and 1990 juvenile surveys.

	Stratum 339 Div. 3Ø		Stratum 353 Div. 3Ø		Stratum 360 Div. 3N		Stratum 359 Div. 3N	
Age	1989	1990	1989	1990	1989	1990	1989	1990
1	598.6	108.8	29.1	83.7	154.0	91.3	14.2	78.5
2	402.1	681.3	37.8	195.3	668.9	184.1	432.2	85.3
3	547.4	376.4	190.1	118.2	1030.6	293.1	1055.5	203.5
4	254.8	654.3	209.2	278.0	867.6	431.2	659.8	305.2
5	196.1	352.7	108.8	215.9	242.9	306.3	131.2	186.6
6	200.4	166.5	71.5	76.6	77.5	74.2	42.7	26.9
7	228.9	123.2	61.2	48.9	16.2	24.8	10.1	7.7
8	173.7	82.2	25.1	24.8	7.2	11.1	2.3	2.8
9	167.7	43.3	16.9	12.9	2.9	4.3	0.5	0.9
10	100.9	26.6	5.9	8.4	2.4	2.3	0.2	0.4
11	58.3	12.8	2.6	5.1	1.9	1.3	0.3	0.1
12	18.2	8.1	2.6	1.3	1.6	0.7	0.0	0.0
13	4.8	0.0	2.4	2.9	1.1	0.5	0.0	0.0
14	8.8	0.0	3.2	1.4	0.5	0.6	0.0	0.0
15	1.4	0.0	3.3	0.5	0.1	0.2	0.0	0.0
16	-		0.9			0.0	0.0	0.0
Total	2961.8	2636.2	770.67	1073.95	3076.01	1426.1	2348.9	897.95

Table 8. Comparison of mean length-at-age of juvenile plaice ages 1-5 years in the 1990 juvenile survey.

Age	Division 3L			Division 3N			Division 3Ø		
(years)	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.
1	19	5.2632	0.6534	86	7.1047	1.5869	97	7.1753	1.7501
2	35	7.5429	1.0387	98	11.9694	2.2312	120	10.7167	3.0103
3	68	10.2794	3.0559	120	15.5583	3.5499	58	15.6034	4.1122
4	103	13.7670	3.5816	171	19.4737	3.9278	123	19.6016	3.9665
5	136	18.5441	4.2214	218	25.6009	4.3828	121	23.9835	3.9157

Table 9. Abundance estimates at age (Nos. X 10^{-3}) from deepwater strata (93–183) on the north and northwest slope of Division 3L from 1989 and 1990 juvenile surveys.

Age	Stratum 348		Stratum 349		Stratum 364		Stratum 365		Stratum 370		Stratum 385		1989 Div. 3L abundance	%	1990 Div. 3L abundance	%
	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990				
1	204.2	123.4	141.4	68.8	347.4	402.8	126.1	268.7	484.7	36.3	2,007.8	3.98	4,092.1	81	2,179.9	87
2	9,518.8	640.0	3,859.1	153.3	14,216.9	7,109.2	14,310.7	649.9	14,521.4	2,146.8	19,289.2	64.5	84,026.4	90	28,602.2	94
3	53,843.4	6,787.5	30,971.0	1,239.9	108,948.2	46,183.6	58,752.1	5,806.2	78,987.9	11,041.5	84,400.5	355.2	456,904.3	91	171,398.7	93
4	63,426.7	25,647.4	40,643.9	6,386.3	117,049.5	169,138.1	53,776.4	21,314.74	79,368.2	28,978.1	70,932.0	748.5	486,705.8	87	476,259.1	92
5	42,076.0	35,236.8	19,461.0	15,452.7	40,229.8	197,045.5	21,689.5	27,904.61	21,698.8	33,318.9	23,442.9	483.2	199,787.6	84	474,838.7	91
6	51,513.5	23,975.1	32,526.8	12,658.9	36,525.1	70,773.0	21,236.7	14,808.9	15,534.2	16,903.3	23,803.5	153.9	223,511.3	81	198,072.3	90
7	51,600.3	28,132.8	44,916.5	19,507.3	29,533.6	66,199.6	15,777.1	13,453.9	9,234.6	19,761.8	17,338.8	107.8	220,242.8	76	194,347.6	90
8	45,468.7	25,771.8	66,944.7	25,116.9	34,115.2	61,877.7	11,458.8	8,221.4	7,411.1	19,784.9	12,830.2	66.6	238,975.8	75	180,805.7	87
9	24,203.4	18,492.4	49,103.8	19,483.7	27,632.1	48,280.7	5,456.0	5,221.8	7,109.0	14,648.6	10,285.4	37.7	196,179.1	63	142,087.9	81
10	5,780.6	6,518.1	9,137.1	7,224.3	8,958.9	28,980.7	1,544.8	2,719.0	3,100.7	6,615.2	4,858.9	13.3	70,054.1	48	777,66.2	71
11	1,724.0	2,197.8	2,178.9	2,560.1	2,684.1	15,371.7	884.0	638.21	1,284.6	2,540.9	1,724.7	4.1	30,210.2	35	41,948.9	58
12	729.1	879.3	1,188.6	696.4	861.5	6,675.3	188.8	463.84	409.2	715.3	770.9	2.6	13,813.3	30	19,113.5	53
13	219.9	–	370.8	87.9	69.2	1,478.3	0.0	73.40	137.7	156.6	180.9	0.4	4,060.6	24	5,703.8	33
14	59.1	–	–	32.1	27.4	238.5	16.6	0.0	27.3	35.9	47.2	0.0	1,350.9	13	1,412.9	22
15	–	–	–	32.10	5.44	23.9	11.07	0.00	0.00	0.00	0.00	0.3	450.4	4	628.6	9
Total	350,367.6	174,402	301,443.4	110,700.7	421,204.1	719,898.1	205,228.7	101,534.8	239,309.4	156,683.9	271,913.1	2,041.9	2,230,545.7		2,015,408.3	

Table 10. Abundance estimates at age (Nos. X 10^{-3}) from plaice catches on the "Tail" of the Bank (Strata 353, 359, and 360) and Whale Deep (Stratum 339) in 1989 and 1990 juvenile surveys.

Age	Stratum 339 Div. 3Ø 1989	Stratum 339 Div. 3Ø 1990	Stratum 353 Div. 3Ø 1989	Stratum 353 Div. 3Ø 1990	1989 Div. 3Ø Total abundance	%	1990 Div. 3Ø Total abundance	%	Stratum 360 Div. 3N 1989	Stratum 360 Div. 3N 1990	Stratum 359 Div. 3N 1989	Stratum 359 Div. 3N 1990	1989 Div. 3N Total abundance	%	1990 Div. 3N Total abundance	%
1	37,222.7	6,767.4	3,970.9	11,407.2	83,699.6	49	41,272.3	44	48,989.9	29,017.6	635.6	3,513.8	52,471.1	95	35,167.0	93
2	25,001.0	42,366.3	5,148.1	26,617.3	110,527.3	27	138,253.7	50	212,756.8	58,545.1	19,342.4	3,815.25	254,035.1	91	78,523.5	79
3	34,041.6	23,404.8	25,898.9	16,102.1	200,706.3	30	80,498.8	49	327,759.6	93,201.5	47,233.8	9,107.7	405,577.8	93	129,542.7	79
4	15,841.8	40,683.8	28,507.5	37,884.2	141,253.9	31	159,963.8	49	275,942.5	137,137.3	29,526.8	13,659.9	332,507.8	92	192,028.2	79
5	12,196.5	21,933.3	14,832.6	29,429.8	72,735.2	37	107,830.3	48	77,252.1	97,421.6	5,869.7	8,350.4	94,497.4	88	143,754.7	74
6	12,459.8	10,356.4	9,747.4	10,432.9	57,262.1	39	44,488.1	47	24,637.9	23,608.8	1,911.6	1,205.2	35,365.6	75	39,017.7	64
7	14,232.2	7,660.3	8,338.9	6,662.7	57,747.1	39	32,509.5	44	5,166.3	7,872.7	450.0	343.7	13,412.4	42	26,017.3	32
8	10,799.5	5,113.6	3,417.5	3,378.8	36,509.3	39	24,003.3	35	2,297.35	3,536.8	104.5	124.3	9,668.4	25	13,991.7	27
9	10,424.9	2,692.2	2,306.6	1,755.6	34,192.2	37	17,143.4	26	947.4	1,361.4	21.6	41.8	5,758.9	17	14,029.1	10
10	6,276.7	1,654.8	814.4	1,148.7	22,269.8	32	15,694.2	18	763.9	739.8	8.2	19.63	6,746.0	12	12,043.8	6
11	3,622.8	792.6	357.4	689.5	18,813.9	21	12,791.3	12	594.1	425.3	12.5	2.7	5,566.3	11	9,848.8	4
12	1,131.0	502.7	351.1	178.5	10,019.2	15	9,357.6	7	493.1	232.9	0	0	2,991.8	17	7,313.2	3
13	300.9	–	319.8	406.1	3,892.8	16	5,468.0	7	363.8	165.9	0	0	2,097.1	17	5,032.7	3
14	543.9	–	438.2	185.2	3,340.8	29	2,577.4	7	166.5	201.6	0	0	775.1	22	3,924.0	5
15	83.5	–	450.6	72.4	1,757.8	36	1,116.0	7	43.5	73.9	0	0	187.5	23	1,474.3	5
16	–	–	121.1	0	734.6	17	448.1	0		10.1	0	0	28.2	0	538.9	2
Total	184,178.7	163,928.1	105,021.1	146,350.8	855,645.7		693,486.9		978,294.8	453,552.1	105,116.8	40,184.4	1,221,861.4		706,326.8	

Table 11. Comparison of weighted average depth and temperature distributions of juvenile plaice in the deepwater strata (348, 349, 364, 365, 370, and 385) in Division 3L; Tail of the Bank (Strata 353, 359, and 360) in 3N and Whale Deep (Stratum 339) in 3Ø for 1989-90 combined.

	Deepwater strata				Tail of the Bank				Whale Deep			
Age	Mean depth (m)	S.D.	Mean temp. (°C)	S.D.	Mean depth (m)	S.D.	Mean temp. (°C)	S.D.	Mean depth (m)	S.D.	Mean temp. (°C)	S.D.
1	129.97	25.05	-1.20	0.17	69.80	11.8	2.20	2.10	109.70	4.37	-0.38	0.27
2	141.25	21.28	-1.21	0.13	70.54	13.97	2.73	2.23	104.73	4.83	-0.17	0.38
3	141.74	20.00	-1.21	0.13	72.23	15.6	2.72	2.38	105.48	5.11	-0.18	0.38

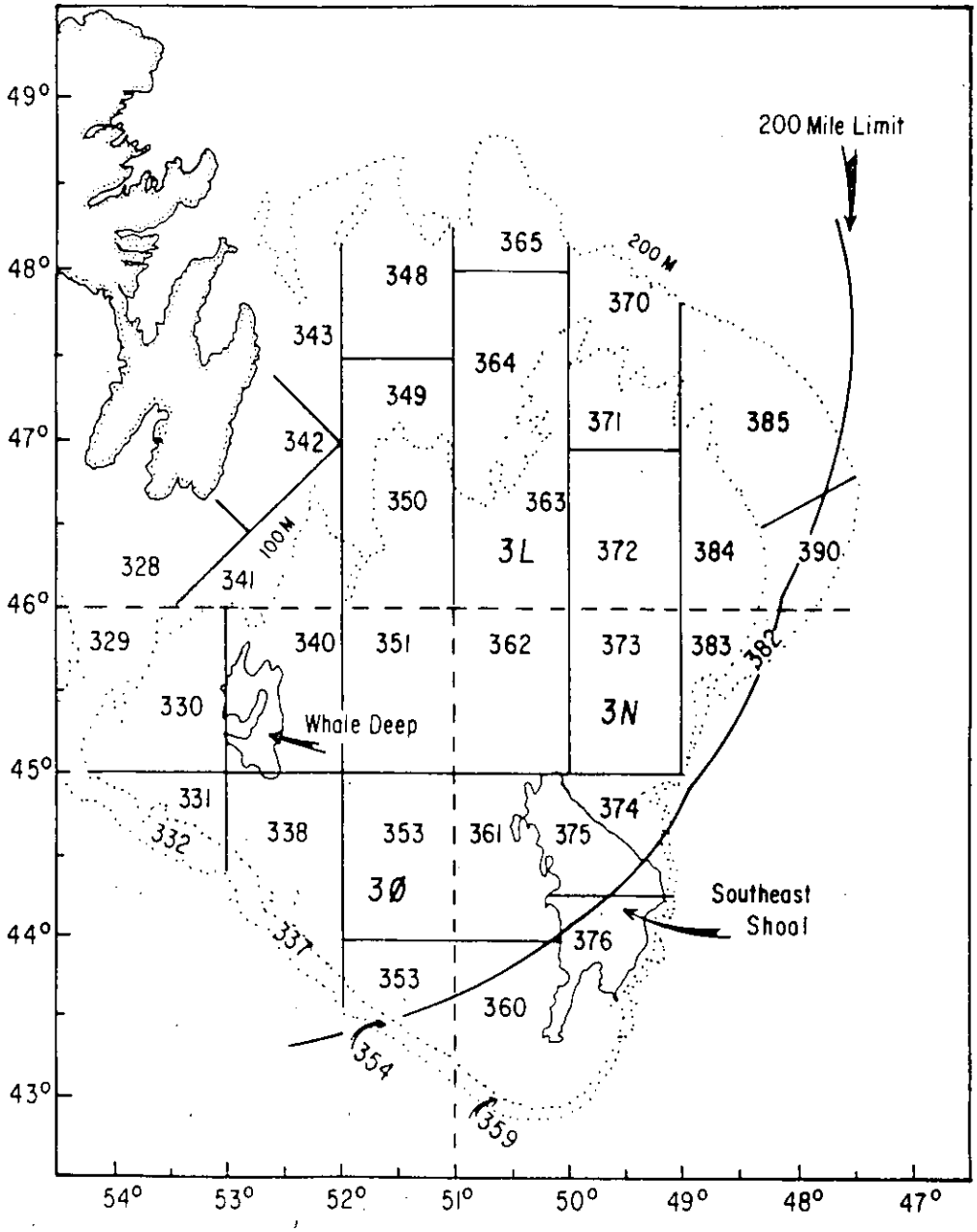


Fig. I. Stratification scheme used in the 1985-90 juvenile surveys of the Grand Bank, NAFO Div. 3LNO

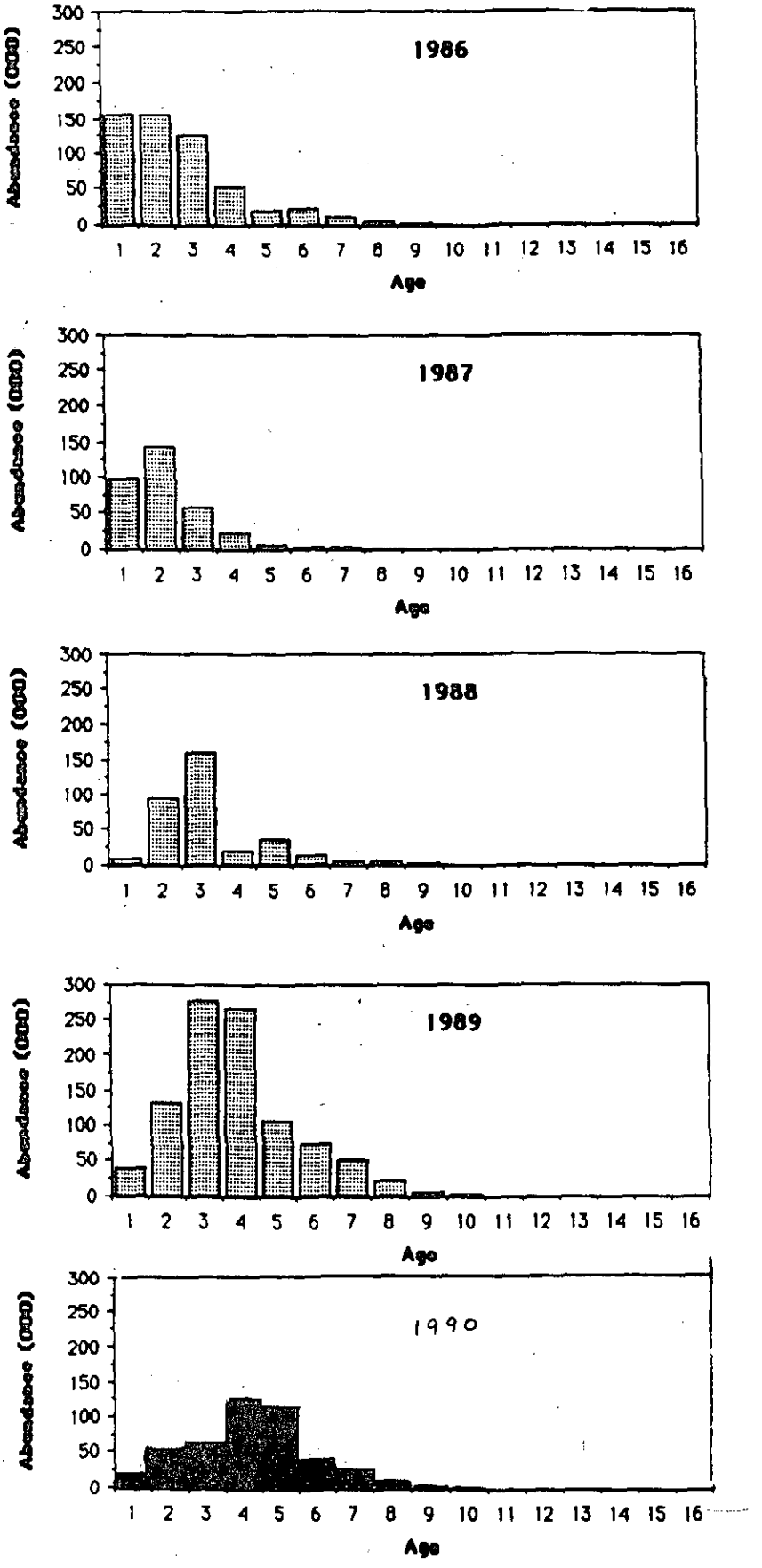
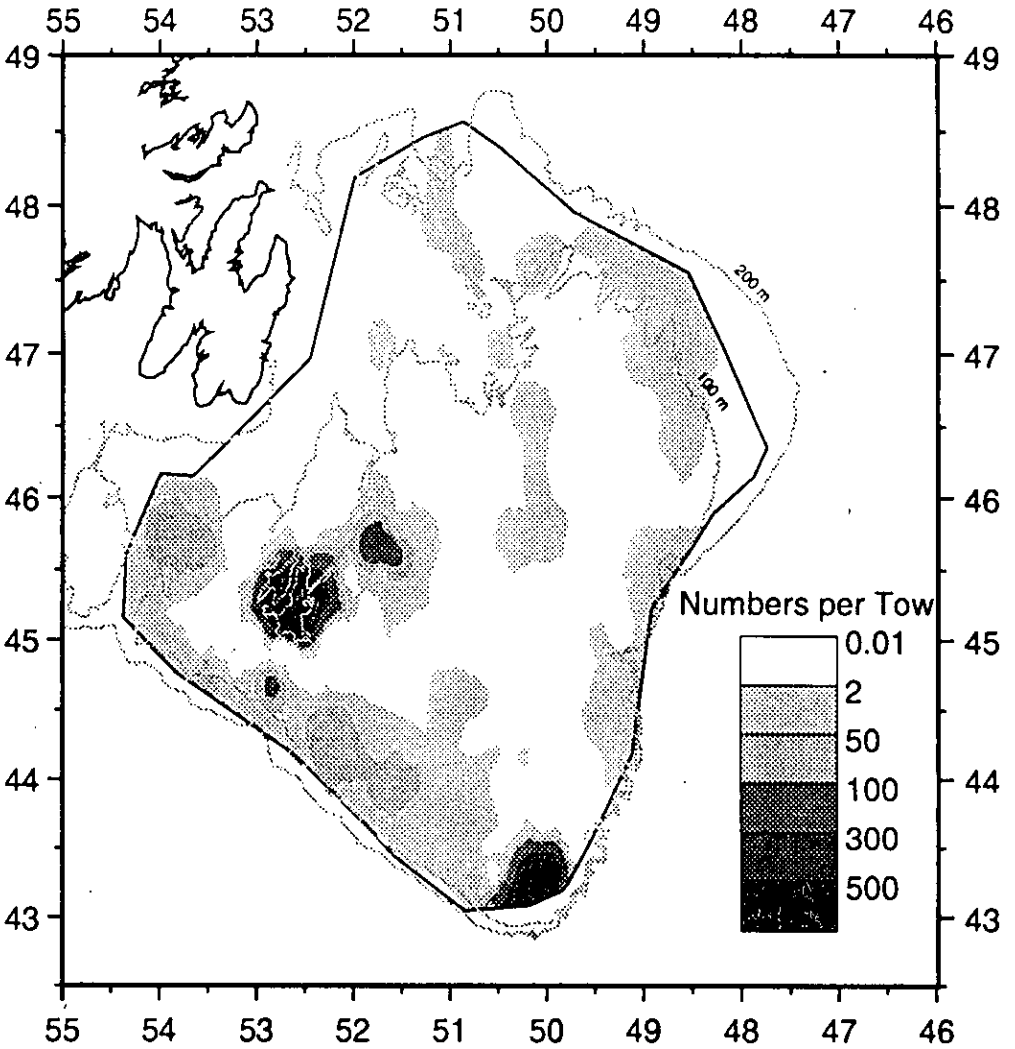


Fig. 2 Abundance at age of American plaice on the Grand Bank from juvenile surveys in Stratum 360 from 1985-90.



Age 1 American plaice, 1989

Fig. 3 Density plots of standard number per tow of plaice in the 1989 juvenile survey.

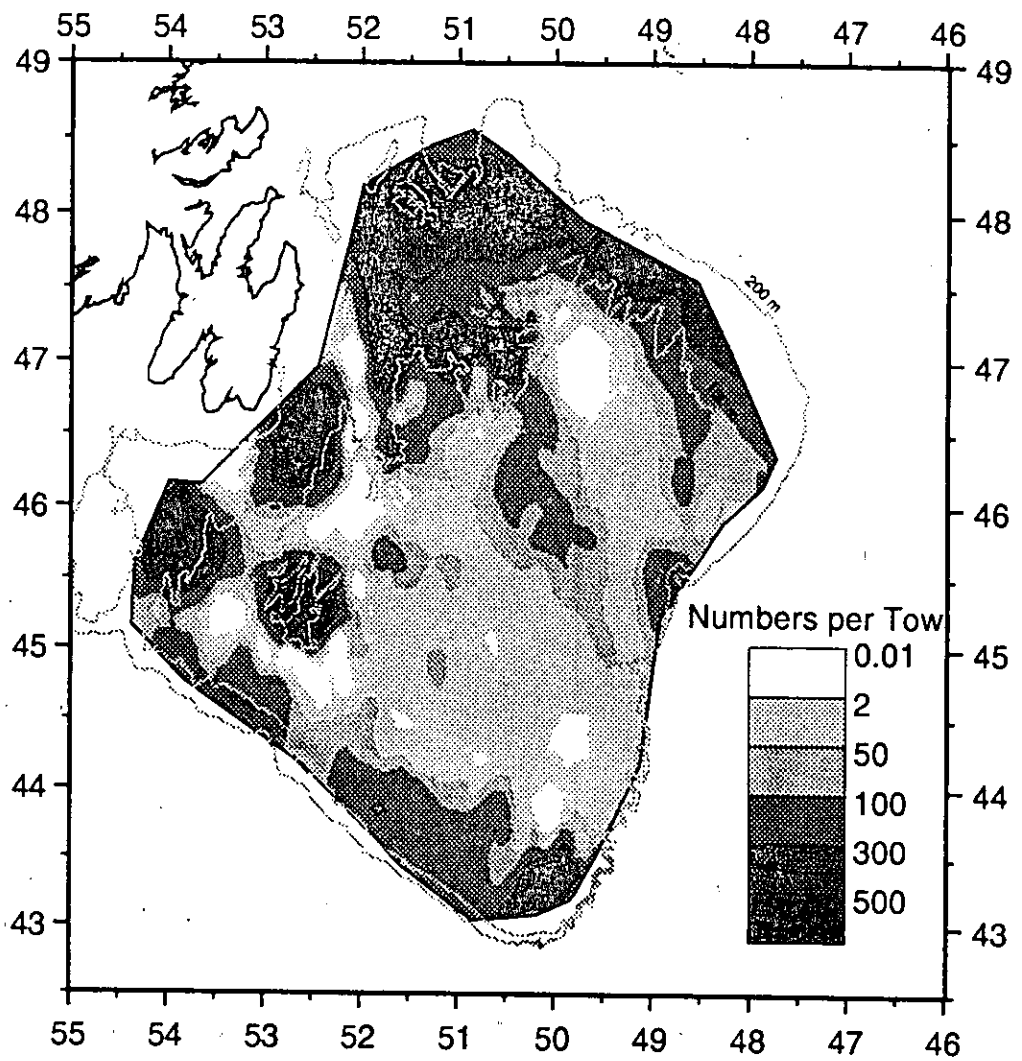


Fig. 4. Density plots of standard number per tow of plaice in the 1989 juvenile survey.

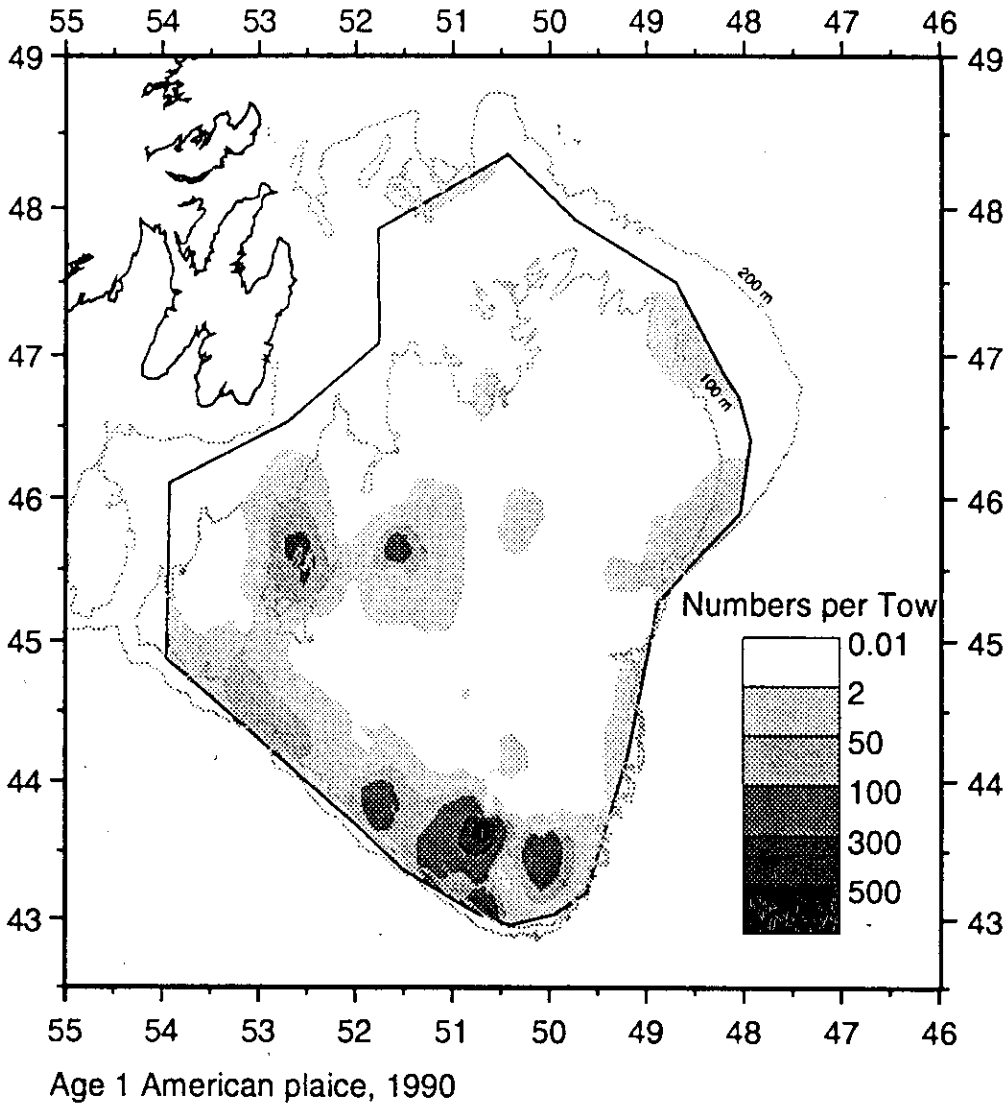


Fig. 5 Density plots of standard number per tow of plaice in the 1990 juvenile survey.

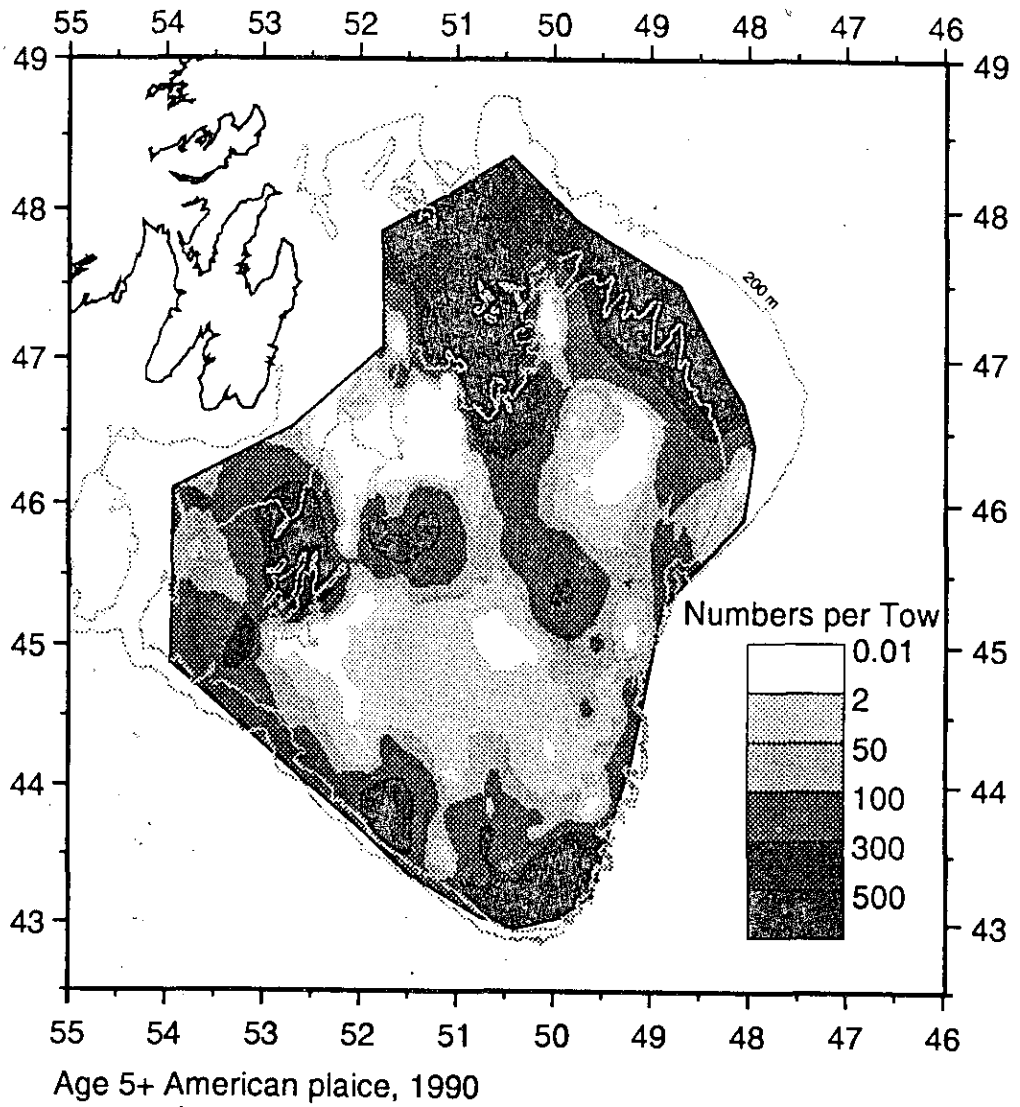


Fig. 6 Density plots of standard number per tow of plaice in the 1990 juvenile survey.